Summary of freshwater mussel timed search surveys in southwestern Ontario in 2010 and 2011

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Freshwater mussel surveys were undertaken by Fisheries and Oceans Canada during 2010 and 2011 in a number of southwestern Ontario rivers. Three sites were sampled in two Thames River tributaries - Baptiste Creek and Jeannette's Creek. A total of 13 animals were found, representing five species, including the Threatened *Quadrula quadrula*. Nine sites were sampled in the Belle and Ruscom rivers and 355 animals were found representing nine different species. Two sites were sampled in the Sydenham River and 19 animals were found representing six species, including *Q. quadrula*. One site was sampled in the Grand River in 2010 and an additional seven were surveyed in 2011. Thirty animals were found, representing four species, including the Endangered *Lampsilis fasciola* in 2010. In 2011, 473 mussels were found representing 17 species including *Q. quadrula* and the Endangered *Pleurobema sintoxia.* Twelve sites were surveyed in the Saugeen River and over 650 animals were found representing eight species, including the Endangered *Villosa iris*. Historical and current species richness were also compared and overall 35 different species have been reported from the Thames and Sydenham rivers, 32 in the Grand River, 6 in the Belle River, 11 in the Ruscom River and 14 in the Saugeen River.

RÉSUMÉ

McNichols-O'Rourke, K. A., Robinson, A. and Morris, T. J., 2012. Summary of freshwater mussel timed search surveys in southwestern Ontario in 2010 and 2011. Can. Manuscr. Rep. Fish. Aquat. Sci. 3009: vi + 42 p.

Des relevés de moules d'eau douce ont été effectués par Pêches et Océans Canada en 2010 et 2011 dans bon nombre de rivières du sud-ouest de l'Ontario. Trois sites ont été échantillonnés dans deux affluents de la rivière Thames – Baptiste Creek et Jeannette's Creek. Un total de 13 animaux, représentant cinq espèces, ont été trouvés, notamment l'espèce menacée la *Quadrula quadrula*. Neuf sites ont été échantillonnés dans les rivières Belle et Ruscom. Un total de 355 animaux, représentant neuf différentes espèces, ont été trouvés. Deux sites ont été échantillonnés dans la rivière Sydenham. Un total de 19 animaux, représentant six espèces, ont été trouvés, notamment la *Q. quadrula*. Un site de la rivière Grand a été échantillonné en 2010 et sept autres ont été étudiés en 2011. En 2010, trente animaux, représentant quatre espèces, ont été trouvés, notamment la *Lampsilis fasciola*, en voie de disparition. En 2011, 473 moules, représentant 17 espèces, ont été trouvées, notamment la *Q. quadrula* et l'espèce menacée, la *Pleurobema sintoxia*. Douze sites ont été étudiés dans la rivière Saugeen. Plus de 650 animaux, représentant huit espèces, ont été trouvés, notamment l'espèce menacée la *Villosa iris*. On a comparé, par ailleurs, la diversité historique et actuelle des espèces, et un total de 35 espèces différentes ont été signalées provenant des rivières Thames et Sydenham, 32 de la rivière Grand, 6 de la rivière Belle, 11 de la rivière Ruscom et 14 de la rivière Saugeen.

1.0 INTRODUCTION

Freshwater mussels are an important part of aquatic ecosystems. They are natural environmental filters and are involved in a number of water column and sediment processes (Vaughn and Hakenkamp 2001). They also provide habitat for algae and invertebrates and transfer energy from aquatic to terrestrial environments via predation (Neves and Odom 1989, Newton et al. 2011). Despite their importance they are among North America's most imperilled species (Ricciardi et al. 1998). Approximately 72% of native North American freshwater mussels are considered Threatened, Endangered or Extinct (Williams et al. 1993). Over 50 species of freshwater mussels are found in Canada and more than 65% of these are in need of conservation (Metcalfe-Smith and Cudmore-Vokey 2004, Metcalfe-Smith et al. 2005). Ontario is home to the highest diversity of mussel species in Canada, with 41 species occurring in the province (Metcalfe-Smith et al. 2005). Thirteen species have been assessed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) as Endangered, Threatened, or Special Concern and an additional two species are currently under assessment (Table 1).

Despite the significance of Ontario's mussel fauna it has remained relatively under studied until recently. Historically, Detweiler's surveys in the summer of 1916 (Detweiler 1918) represent the earliest large scale systematic surveys for unionids in the province though there appears to have been only scattered work carried out in the following decades leading to the summary of LaRocque and Oughton (1937). Interest in mussels of the Great Lakes rose through the middle part of the last century (Wood 1963, Wood and Fink 1984, Wright 1955) culminating with the catastrophic invasion of Dreissenid mussels in the 1980's (Nalepa et al. 1996). However the inland rivers and streams remained relatively understudied with the exception of the nationally recognized Sydenham River; (Clarke 1992, Mackie and Topping 1988) and one study on the Grand River (Kidd 1973). Significant surveys of other Ontario rivers began in earnest in the 1990s (Mackie 1996, Metcalfe-Smith et al. 1997, Metcalfe-Smith et al. 1998a, Metcalfe-Smith et al. 2000b, Morris 1996, Morris and DiMaio 1998, Schueler 1996) largely in response to the increased awareness about the conservation status of freshwater mussels in general (Metcalfe-Smith et al. 1998b) and specifically in relation to losses of the Great Lakes populations following the invasion of Zebra Mussels (Nalepa et al. 1996). By the end of 2010 most of the large inland rivers of southwestern Ontario including the Sydenham (Clarke 1992, Mackie and Topping 1988, Metcalfe-Smith et al. 2003), Thames (Morris 1996, Morris and Edwards 2007), Grand (Kidd 1973, Mackie 1996, Metcalfe-Smith et al. 2000b), Welland (Morris et al. 2012a), Ausable (Morris and DiMaio 1998), Bayfield (Morris et al. 2012b), Maitland (McGoldrick and Metcalfe-Smith 2004), Saugeen (Morris and DiMaio 1998, Morris et al. 2007), and Nottawasaga (Minke-Martin et al. 2012) had been systematically surveyed.

It is vital that surveys are completed to determine the status of mussel populations, to monitor changes in distributions and demographics and to fill in knowledge gaps so that the appropriate steps are taken to ensure the survival and recovery of these species. The surveys described here and undertaken in 2010 and 2011 represent initial surveys in two smaller systems (Belle and Ruscom rivers) as well as additional surveys

in the larger Sydenham, Grand, Thames and Saugeen rivers specifically designed to address species-specific questions and fill in knowledge gaps. Given that six different rivers were surveyed throughout the 2010 and 2011 field season, including the three largest systems in southwestern Ontario – the Thames, Sydenham and Grand rivers. a unique opportunity was created to compare historical and current mussel species richness across these systems.

2.0 METHODS

2.1 STUDY SITES

2.1.1 Thames River

The Thames River is the second largest watershed in southwestern Ontario, draining 5,285 km² of land into Lake St. Clair (CHRS 2011). Thirty-five species of freshwater mussels have been reported (shells or live) from the Thames River (see Table 2 for details), including 12 COSEWIC assessed Species at Risk (SAR) mussels: *Epioblasma torulosa rangiana* (Northern Riffleshell), *Epioblasma triquetra* (Snuffbox), *Lampsilis fasciola* (Wavyrayed Lampmussel), *Obovaria olivaria* (Hickorynut), *O. subrotunda* (Round Hickorynut), *Pleurobema sintoxia* (Round Pigtoe), *Ptychobranchus fasciolaris* (Kidneyshell), *Quadrula quadrula* (Mapleleaf), *Simpsonaias ambigua* (Salamander Mussel), *Truncilla donaciformis* (Fawnsfoot), *Villosa fabalis* (Rayed Bean) and *Villosa iris* (Rainbow Mussel; COSEWIC 2010b, c, Lower Great Lakes Unionid Database 2011, Mackie 2007, Metcalfe-Smith et al. 1997, Morris and Edwards 2007). Currently there are 30 extant species in the Thames River watershed including seven SAR: *L*. *fasciola*, *P*. *sintoxia*, *P*. *fasciolaris*, *Q*. *quadrula*, *T*. *donaciformis*, *V*. *fabalis* and *V*. *iris*. Since sampling of the lower tributaries has been limited and infrequent, three sites were surveyed, two in Baptiste Creek and one in Jeannette's Creek (Figure 1, Appendix A). These two tributaries flow through fertile agricultural land south of Chatham where they empty into the lower Thames River before it reaches Lake St. Clair. Like this section of the Thames River, they exhibit a low gradient with fine-textured substrate (Chapman and Putnam 1984).

2.1.2. Belle and Ruscom rivers

The Belle River and the Ruscom River (Figure 2) are tributaries of Lake St. Clair with areas of 113.6 km^2 and 174.7 km^2 respectively (ERCA 2010). Over 30 species of freshwater mussels historically occurred in Lake St. Clair and at least 21 of these remain in the delta area (Metcalfe-Smith et al. 2004). Six species of freshwater mussels have been reported from the Belle River. This includes one mussel SAR, *O. subrotunda*; however, the historical record does not include any information specifying the number found, or whether the animals were found alive or as shells. Currently, there are four extant species found in the Belle River and none are SAR (Table 2). Eleven species have been reported from the Ruscom River, nine of which are extant, including one SAR, *Q*. *quadrula*. A total of nine sites were surveyed on the Belle (n = 3)

and Ruscom (n = 6) rivers (Appendix A). The Belle and Ruscom rivers drain northward into the southern shores of Lake St. Clair near Tecumseh and Windsor. Their headwaters wind through agricultural land beginning north of Leamington, with residential development increasing with proximity to the Lake. Upon reaching the residential areas, the rivers are both almost entirely channelized, and on such a minimal gradient that they often flow upstream from Lake St. Clair.

2.1.3 Sydenham River

The Sydenham River (Figure 1) is a large river system encompassing a 2,700 km^2 watershed. The river has a north (160-km long) and an east branch (200-km long) that meet in Wallaceburg and drain into Lake St. Clair (Dextrase et al. 2003). The Sydenham River lies completely in the Carolinian Life Zone and is relatively undisturbed by industrial development. Land use is predominantly (85%) agriculture (Dextrase et al. 2003). Thirty-five species have been reported from the Sydenham River including 12 COSEWIC assessed SAR: *E*. *t*. *rangiana*, *E*. *triquetra*, *L*. *fasciola*, *Ligumia nasuta* (Eastern Pondmussel), *O*. *subrotunda*, *P*. *sintoxia*, *P*. *fasciolaris*, *Q*. *quadrula*, *S*. *ambigua*, *T*. *donaciformis*, *V*. *fabalis*, and *V*. *iris* (Table 2). Currently, there are 32 extant species accounted for including ten of the SAR listed above. *Lampsilis fasciola* is represented by weathered shells only and no current records exist for *L*. *nasuta*. Two sites were surveyed near Tupperville in the east branch of the Sydenham River during the 2011 field season (Appendix B) in an effort to confirm the presence of *Toxolasma parvum* (COSEWIC candidate species).

2.1.4 Grand River

The Grand River is the largest watershed in southern Ontario, draining ~ 6,965 km^2 of land into Lake Erie (GRCA 2012). Thirty-two species of mussels have been reported from the Grand River watershed, including 10 SAR: *E*. *triquetra*, *L*. *fasciola*, *L*. *nasuta*, *O*. *olivaria*, *O*. *subrotunda*, *P*. *sintoxia*, *P*. *fasciolaris*, *Q*. *quadrula*, *T*. *donaciformis*, and *V*. *iris* (Table 2). Recent surveys have shown that there are 26 extant species including five SAR: *L*. *fasciola*, *P*. *sintoxia*, *Q*. *quadrula*, *T*. *donaciformis*, and *V*. *iris*. One site was sampled in 2010 downstream of Glen Morris (Figure 3, Appendix A). An additional seven sites were surveyed in 2011 (Figure 3, Appendix B).

2.1.5 Saugeen River

The Saugeen River watershed drains 3,992 km^2 of land into Lake Huron (Martha Nicol, Saugeen Conservation 1078 Bruce Road 12 Box 150 Formosa, Ontario, N0G 1W0 pers. comm.). Fourteen species of mussels have been reported from the Saugeen River watershed, ten of these extant, including two mussel SAR, *T*. *donaciformis* and *V*. *iris* (Table 2). Twelve sites were sampled in the Saugeen River watershed during the 2011 field season, eight in the Teeswater River, one in the main stem of the Saugeen River, two in the North Saugeen River and one in the Beatty Saugeen River (Figure 4, Appendix C).

2.2. SURVEY METHODS

Several physical and environmental variables were recorded at each site. These variables included substrate composition, water clarity, length of reach, mean stream depth and width. Substrate percent cover was visually estimated and water clarity was either visually estimated or measured using a turbidity tube. The remaining variables were measured using a metre stick. Definitions of substrate sizes were modified from Wentworth (1922): boulder (>250 mm in diameter), rubble (60-250 mm), gravel (20-50 mm), sand (<2 mm) and "other" material (mud, muck, silt, and detritus).

Sites were visually surveyed using the intensive timed-search technique of Metcalfe-Smith et al. (2000a). At each site the substrate was surveyed, using visual or tactile techniques, to the maximum wading depth by a team moving parallel to the river bank for a total of 4.5 person-hours per site. Search times may have varied at different sites depending on stream conditions (Appendices A,B,C). During the surveys all live animals were removed from the substrate and placed in a mesh diver's bag. At the end of the sampling period, mussels from all collectors were combined, identified, sexed (if possible), and returned to the river.

3.0 RESULTS

3.1 ABIOTIC FACTORS

Details of site locations, effort and collectors are presented in Appendices A, B, and C. Tables 3-5 provide a summary of the physical data collected during the 2010 and 2011 surveys. These data were not meant to address issues relating to species microhabitat preferences but rather to provide a general description of the site and assist future researchers in locating the exact site should further surveys be required. The substrate of the three sites surveyed in Baptiste and Jeannette's creeks (Thames River watershed) was generally less than 50 mm in size (Table 3). Water clarity was variable depending on the site. The Belle and Ruscom river substrates consisted of typically fine-textured substrate although there was some combination of larger textures, most ranging from rubble to sand. The water clarity was variable depending on the site. The two Sydenham River sites, surveyed in 2011, were made up of gravel and "other" (muck, mud, silt, and detritus) material as well as clay (Table 4). Water clarity at the Sydenham River sites was 0.32 and 0.18 m at SR-21 and SR-22 respectively. The 2010 Grand River site had a variety of substrate textures (Table 3), whereas those sites surveyed in 2011 consisted of a large proportion of "other" material (Table 4). The water clarity ranged from 0.19-0.85 m, however the river bottom was visible at all sites. Of the 12 sites surveyed on the Saugeen River substrate data were collected at five and most had a high percentage of rubble (Table 5). Substrate data were not collected for the remaining seven sites as they were "scouting" sites. If the site contained suitable mussel habitat, it was revisited and data were collected using the quadrat survey method (this information will be presented in a different manuscript report). The water clarity throughout these sites ranged from 0.26 to > 1.2 m.

3.2 FRESHWATER MUSSEL COMMUNITY

A total of 398 mussels of 14 species were found during the 2010 surveys. Over 1150 animals representing over 20 species were found during the 2011 field season. Table 2 represents the historical (pre-1997) and current (1997 on) species richness for each river surveyed in 2010 and 2011.

3.2.1 Thames River

A total of 13 animals representing five species, were collected in the two Thames River tributaries (Table 6). Twelve of these were found at site TR-55 in Baptiste Creek. No mussels were found at the second site (TR-54) surveyed in this creek, therefore it is not included in Table 6. The dominant species was *Q*. *quadrula*, a SAR, making up almost 70% of animals found. The lengths of the nine *Q*. *quadrula* ranged from 49 -110 mm. The four remaining species were represented by one individual each - *Toxolasma parvum* (Lilliput), *Truncilla truncata* (Deertoe), and *Utterbackia imbecillis* (Paper Pondshell) from TR-55 and *Pyganodon grandis* (Giant Floater), from TR-56. Fresh shells of *Lasmigona complanata* (White Heelsplitter) were also observed at TR-56; however, no live individuals of this species were found.

3.2.2 Belle and Ruscom rivers

The highest abundance of mussels found during the 2010 surveys was in the Ruscom River. A total of 340 mussels representing eight species were found during these surveys (Table 7). Fifteen individuals representing four species were observed in the Belle River. Fresh shells of *L*. *complanata* and *P*. *grandis* were found at two sites, BLR-02 and RS-01; however, no other shells or live individuals were observed. RS-04 on the Ruscom River had greatest abundance (number of individuals) and species richness (total number of mussel species observed) in 2010, despite recent bridge construction that left large boulders acting as a barrier under the bridge, as well as some bank instability due to sheep grazing in and around the river. The dominant species in the Ruscom River was *Lampsilis siliquoidea* (Fatmucket), making up 67% of all mussels found. Figure 5 shows the size frequency distributions for *L*. *siliquoidea* (males, females and juveniles) observed at RS-02 and RS-04. The male to female ratio was approximately 1.5:1. *Lasmigona complanata* had the widest distribution occurring at 44% of the sites surveyed (Table 7). Twenty-six *Q*. *quadrula* were observed at two sites in the Ruscom River. This species is not sexually dimorphic, therefore Figure 6 shows the length frequency distribution for all individuals that were measured. *Toxolasma parvum* was also recorded alive at one site in the Belle River and one site in the Ruscom River.

3.2.3 Sydenham River

Nineteen animals representing six extant species were collected at the two sites surveyed in the Sydenham River in 2011 (Table 8). Site SR-22 had the highest abundance (15) and species richness (5), including a single *Q*. *quadrula*. The most abundant species was *T*. *parvum*, which had ~ 37% relative abundance at SR-22.

3.2.4 Grand River

Thirty animals representing four species were collected in the Grand River surveys in 2010, including *L*. *fasciola* (Table 9). A total of eight *L*. *fasciola* individuals were found – seven females and one male. *Lasmigona costata* was the species with the highest relative abundance representing over half of the individuals collected at this site.

In 2011, two different surveys occurred, the first of which was a scouting survey. The results of these scouting surveys are presented in Table 10, however, these data are excluded from further discussion in this report. The objective of these scouting surveys was to determine if the site contained suitable habitat for mussel species - if habitat was suitable then a second, timed search, survey took place and it is these results that are discussed below.

A total of 473 individuals representing 17 extant species were observed in the Grand River during the timed search surveys (Table 11). Total abundance at each site ranged from eight to 370. This included eight federally Endangered *P*. *sintoxia* with lengths ranging from 66 to 102 mm. Species richness among the sites ranged from two to 13 species. Site GR-06 had the highest abundance at 370 individuals and also had the highest species richness at 13 (Table 11). A total of 102 *Actinonaias ligamentina* (Mucket) were found, making it the most abundant species (21% relative abundance). The size distribution of *A*. *ligamentina* is shown in Figure 7. The most widely distributed species was the Threatened *Q. quadrula*, as it occurred at 100% of the sites. The lengths of the 34 individuals found ranged from 57 to 134 (Figure 8). Weathered valves of the Endangered *T*. *donaciformis* were also observed at two of the five sites surveyed. Shells of *T*. *parvum* were observed at site GR-17. *Obliquaria reflexa* (Threehorn Wartyback) shells were observed at two sites and live individuals were observed at an additional two sites in the Grand River.

3.2.5 Saugeen River

Over 688 animals representing eight extant species were collected at 12 different sites during the Saugeen River survey (Table 12). Total abundance varied from zero at two sites to over 200 at two sites. Species richness was low at all sites, again ranging from zero to a high of seven species. The site with the highest abundance was SG14, which had a species richness of two, with *Elliptio dilatata* (Spike) representing over 90% of the individuals observed. Importantly, the remaining 24 individuals were the Endangered V*. iris*. The overall most abundant and widely distributed species (82% relative abundance, 67% frequency of occurence) was *E*. *dilatata*. Figure 9 shows the length frequency distribution of 532 *E. dilatata* that were measured. The second most abundant and widely distributed species was *V. iris*, which represented 8% relative abundance and occurred at 50% of all sites surveyed. Figure 10 shows the length frequency for individuals of this species that were measured.

4.0 DISCUSSION

The 2010-2011surveys were completed to fill in knowledge gaps regarding the mussel fauna of these rivers. Some of these sites had not been previously sampled, had low sampling effort, or had inadequate historical records of mussel species, particularly regarding species that are considered at risk. Many common mussel species communities appear to be healthy due to the large number of individuals found (e.g., *L*. *siliquoidea* in the Ruscom River, *A. ligamentina* in the Grand River, *E. complanata* in the Saugeen River). Many of these species also showed multiple size classes, which suggests that reproduction and recruitment are occurring. It is mostly likely that more juveniles would have been found if another technique had been used during the survey. The timed search method is insufficient for detecting juvenile mussels.

Two species are currently undergoing assessment by COSEWIC, *T. parvum* and *O. reflexa*. *Toxolasma parvum* was found at one site each in the Belle and Ruscom rivers, representing the first live records for *T*. *parvum* in these two rivers. This species was also observed in Baptiste Creek and although this is the first record for this species at this location, it has been found, historically, in the Thames River watershed (Lower Great Lakes Unionid Database 2011). This species was also observed in the Sydenham River and there is one historical record for this species at this particular site. *Obliquaria reflexa* was found alive at two sites in the Grand River and shells were observed at an additional two sites during the 2011 sampling period. Although there are historical records for this species in the Grand River, very little information is associated with them, therefore the information collected during these surveys will help to fill in knowledge gaps associated with this species.

Two SAR were observed during the 2010 surveys. *Quadrula quadrula* was found in Baptiste Creek and in the Ruscom River and *L*. *fasciola* in the Grand River. Three SAR were found during the 2011 surveys – *P*. *sintoxia* in the Grand River, *Q. quadrula* in the Sydenham and Grand rivers and *V*. *iris* in the Saugeen River.

4.1 *Lampsilis fasciola* (Wavyrayed Lampmussel)

In 1999, *L*. *fasciola* was assessed as Endangered by COSEWIC; however, it was re-assessed in 2010 and is now Special Concern (COSEWIC 2011). This change in assessment was attributed to the discovery of previously unknown reproducing populations and a general improvement in abundance across its range (COSEWIC 2010a). Currently, *L*. *fasciola* is provincially designated as Threatened under the Ontario *Endangered Species Act* (ESA) and federally designated as Endangered under the *Species at Risk Act* (SARA) in Canada (though it is being considered for down-listing to Special Concern under SARA). *Lampsilis fasciola* is well known from the main stem of the Grand River as it is one of the largest and healthiest reproducing populations in Ontario (COSEWIC 2010a). The presence of *L. fasciola* at GR-36 does, however, represent a distribution extension as this is the furthest downstream site where this species has been observed to date.

4.2 *Pleurobema sintoxia* (Round Pigtoe)

Pleurobema sintoxia was assessed as Endangered by COSEWIC in 2004 (COSEWIC 2011). It is legally designated as Endangered by the Ontario Ministry of Natural Resources under the ESA (OMNR 2011) and under the federal SARA (Species at Risk Public Registry 2011). Historically this species occurred in the Niagara, Detroit, Grand, Thames, and Sydenham rivers, as well as Lake Erie and Lake St. Clair. However, it has been lost from approximately 54% of its historical range (COSEWIC 2004). Declines are attributed to invasive species, and pollution (industrial, municipal, and agricultural; COSEWIC 2004). Currently, there are remnant populations in the Grand and Thames rivers and lakes Erie and St. Clair. Evidence suggests that there are small, reproducing populations in the Sydenham River and in the delta area of Lake St. Clair (COSEWIC 2004). *Pleurobema sintoxia* were found at two sites in the Grand River during the current study. Importantly, no live individuals were found at GR-05 (Lower Great Lakes Unionid Database 2011) during surveys in 1997 and two were found during the current sampling period. Furthermore, only one live individual had been found in previous surveys at GR-06, whereas six individuals were found during the present survey. Additional sampling efforts are required to determine if the *P. sintoxia* population in the Grand River is reproducing or functionally extirpated (no reproduction associated with the adult mussels).

4.3 *Quadrula quadrula* (Mapleleaf Mussel)

Quadrula quadrula was assessed as Threatened in Ontario and Endangered in Manitoba by the COSEWIC in 2006 (COSEWIC 2011). It is now legally designated as Threatened by the Ontario Ministry of Natural Resources under the ESA (OMNR 2011). Historically this species occurred in the Detroit, Sydenham, Thames, Grand, Welland and Niagara rivers as well as Lake Erie and Lake St. Clair; however, it has been lost from approximately 49% of its historical distribution in Ontario (COSEWIC 2006b). Declines are attributed to habitat loss and degradation, invasive species, and pollution (urban, industrial, municipal, and agricultural; COSEWIC 2006b). Currently, *Q*. *quadrula* is found in the Bayfield, Ausable, Sydenham (North and East branch), Thames, Grand, and Welland rivers (COSEWIC 2006b, Morris et al. 2012a, b). The presence of *Q*. *quadrula* in multiple size classes in the Ruscom River suggests some evidence of recruitment; however, further surveys are required to determine population status. This species has been found previously in the lower Thames River, and although this is the first record for this species in Baptiste Creek, it supports the claim that *Q*. *quadrula* is found throughout most of the lower Thames River watershed (COSEWIC 2006b). *Q. quadrula* is known from the Sydenham River where there is evidence of recruitment (COSEWIC 2006b).

4.4 *Villosa iris* (Rainbow Mussel)

Villosa iris was assessed as Endangered by COSEWIC in 2006 (COSEWIC 2011). It is now legally designated as Threatened by the Ontario Ministry of Natural Resources under the ESA (OMNR 2011). Historically this species was widespread and occurred in the the Ausable, Bayfield, Detroit, Grand, Maitland, Moira, Niagara, Salmon,

Saugeen, Sydenham, Thames and Trent rivers, as well as lakes Huron, Ontario, Erie and St. Clair. Evidence suggests that *V. iris* has been extirpated from the lower Great Lakes and connecting channels (except for the Lake St. Clair delta). However, extant populations continue to occur in the rivers listed above (COSEWIC 2006a). Declines have been attributed extensively to the invasive Zebra Mussel and also include sediment and nutrient loading and toxic substances from both urban and agricultural activities (COSEWIC 2006a). Prior to this survey, only 16 live *V. iris* individuals had been recorded from the Saugeen River (Lower Great Lakes Unionid Database 2011). The present study has confirmed the existence of an extant population in the Saugeen River demonstrating a size distribution indicative of ongoing reproduction and recruitment.

4.5 Species richness among rivers

The collection of information, such as species richness, has provided a unique opportunity to compare historical and current differences among several different watersheds, specifically in this case, the Thames, Sydenham and Grand rivers. These three, large, rivers all support a high number of mussel species. Of the 41 species found in Ontario, 85% have been recorded from the Thames and Sydenham rivers and 78% have been recorded from the Grand River. The Sydenham River has often been referred to as the most important mussel system in Canada (Clarke 1992, Metcalfe-Smith et al. 2003), because of the belief that this system contained a greater species richness than any other system in Canada. It is now clear, after sufficient sampling in all systems, that both the Sydenham and Thames rivers were, historically equally rich systems with 35 species. The Grand River also had high species richness with 32 species occurring in the watershed (Table 2). Current species assemblages are close among these three rivers in terms of overall numbers though important differences exist in faunal composition (Table 2). Undoubtedly, the species assemblages of these rivers have been shaped by a variety of factors ranging from past glacial events and subsequent recolonizations (Schwalb et al. 2012) to more recent human activities including commercial harvests on the Grand and Thames rivers (Morris and King 2012) and urban and agricultural activities throughout the watersheds (DFO 2011).

5.0 CONCLUSION

The 2010 and 2011 surveys were completed to fill in knowledge gaps and attempt to assess the freshwater mussel fauna of these rivers. These surveys were successful in that they provided additional data on mussel species (common species and SAR) located in a number of southwestern Ontario rivers. Specific results on mussel SAR include an extension of the current distribution of *L. fasciola* in the Grand River, the continued existence of large *P. sintoxia* individuals in the Grand River, range expansions for *Q. quadrula* in the Thames River and increased abundance in the Ruscom River, and the confirmation of the existence of a reproducing population of *V. iris* in the Saugeen River. Although four SAR were observed during the 2010 and 2011 field seasons, questions remain regarding the status of others. Additional intensive surveys are required to positively ascertain the status of mussels in these watersheds.

Finally, surveys such as this make it possible to determine the overall species composition of different rivers and attempt to reveal changes that have or are occurring within these systems. It is apparent that there are multiple species rich rivers in Ontario and all are important systems for ensuring survival and recovery of unionid mussels.

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Table 1. Mussel Species at Risk in Ontario (as of March 2012). Assessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Designation under the federal *Species at Risk Act* (SARA) and the provincial *Endangered Species Act* (ESA). UC is "under consideration".

Species		COSEWIC (Assessment)[1]	*SARA* (Federal)[2]	*ESA* (Provincial)[3]
Epioblasma torulosa rangiana	Northern Riffleshell	Endangered	Endangered	Endangered
Epioblasma triquetra	Snuffbox	Endangered	Endangered	Endangered
Lampsilis fasciola	Wavyrayed Lampmussel	Special Concern	Endangered	Threatened
Ligumia nasuta	Eastern Pondmussel	Endangered	UC	Endangered
Obliquaria reflexa	Threehorn Wartyback	UC		
Obovaria olivaria	Hickorynut	Endangered	UC	Endangered
Obovaria subrotunda	Round Hickorynut	Endangered	Endangered	Endangered
Pleurobema sintoxia	Round Pigtoe	Endangered	Endangered	Endangered
Ptychobranchus fasciolaris	Kidneyshell	Endangered	Endangered	Endangered
Quadrula quadrula	Mapleleaf	Threatened	UC	Threatened
Simpsonaias ambigua	Salamander Mussel	Endangered	Endangered	Endangered
Toxolasma parvum	Lilliput	UC		
Truncilla donaciformis	Fawnsfoot	Endangered	UC	Endangered
Villosa fabalis	Rayed Bean	Endangered	Endangered	Endangered
Villosa iris	Rainbow	Endangered	UC	Threatened

[1] (COSEWIC 2011)
[2] (Species at Risk Public Registry 2011)
[3] (OMNR 2011)

Table 2. Historical (H) and current (C) species occurrence in the Thames River (T), Sydenham River (S), Grand River (G), Belle River (B), Ruscom River (R) and Saugeen River (SG) watersheds. Data were collected from a variety of sources listed in the text. Bold text are species that have been assessed by COSEWIC.

Scientific Name	Common Name	TH	TC	SH	SC	GH	GC	BH	BC	RH	RC	SGH	SGC
Actinonaias ligamentina	Mucket	Y	Y	Y	Y	Y	Y	-	-	-	-	SH	SH
Alasmidonta marginata	Elktoe	Y	Y	Y	Y	Y	Y	-	-	-	-	Y	Y
Alasmidonta undulata	Triangle Floater	-	-	-	-	-	-	-	-	-	-	-	-
Alasmidonta viridis	Slippershell Mussel	Y	Y	Y	SH	Y	Y	-	-	-	-	-	Y
Amblema plicata	Threeridge	Y	Y	Y	Y	Y	Y	-	-	-	-	-	-
Anodontoides ferussacianus	Cylindrical Papershell	Y	Y	Y	Y	Y	Y	-	-	-	Y	-	-
Cyclonaias tuberculata	Purple Wartyback	SH	Y	Y	Y	-	-	-	-	-	-	-	-
Elliptio complanata[1]	Eastern Elliptio	-	-	-	-	Y	-	-	-	-	-	-	-
Elliptio crassidens	Elephantear	-	-	-	-	-	-	-	-	-	-	-	-
Elliptio dilatata	Spike	Y	Y	Y	Y	Y	Y	-	-	-	-	Y	Y
Epioblasma torulosa rangiana	**Northern Riffleshell**	**SH**	**-**	**Y**	**Y**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Epioblasma triquetra	**Snuffbox**	**SH**	**SH**	**Y**	**Y**	**Y**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Fusconaia flava	Wabash Pigtoe	Y	Y	Y	Y	Y	Y	-	-	-	-	-	-
Lampsilis cardium	Plain Pocketbook	Y	Y	Y	Y	SH	Y	-	-	-	-	SH	Y
Lampsilis fasciola	**Wavyrayed Lampmussel**	**Y**	**Y**	**Y**	**SH**	**Y**	**Y**	**-**	**-**	**-**	**-**	**-**	**-**
Lampsilis radiata[1]	Eastern Lampmussel	Y	-	-	-	SH	-	-	-	-	-	-	-
Lampsilis siliquoidea	Fatmucket	Y	Y	Y	Y	Y	Y	-	-	-	Y	Y	Y
Lasmigona complanata	White Heelsplitter	Y	Y	Y	Y	Y	-	-	Y	-	Y	-	SH
Lasmigona compressa	Creek Heelsplitter	Y	Y	Y	Y	Y	Y	-	-	-	-	Y	Y
Lasmigona costata	Flutedshell	Y	Y	Y	Y	Y	Y	-	-	-	-	SH	Y
Leptodea fragilis	Fragile Papershell	Y	Y	Y	Y	Y	Y	-	SH	-	Y	-	-
Ligumia nasuta	**Eastern Pondmussel**	**-**	**-**	**Y**	**-**	**SH**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Ligumia recta	Black Sandshell	SH	Y	Y	Y	Y	Y	-	-	-	Y	-	-
Obliquaria reflexa	Threehorn Wartyback	Y	Y	-	Y	SH	Y	-	-	-	-	-	-

Scientific Name	Common Name	TH	TC	SH	SC	GH	GC	BH	BC	RH	RC	SGH	SGC
Obovaria olivaria	**Hickorynut**	**SH**	**-**	**-**	**-**	**Y**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Obovaria subrotunda	**Round Hickorynut**	**SH**	**SH**	**Y**	**Y**	**SH**	**-**	**Y**	**-**	**-**	**-**	**-**	**-**
Pleurobema sintoxia	**Round Pigtoe**	**Y**	**Y**	**Y**	**Y**	**SH**	**Y**	**-**	**-**	**-**	**-**	**-**	**-**
Potamilus alatus	Pink Heelsplitter	Y	Y	Y	Y	Y	Y	-	-	-	Y	-	SH
Ptychobranchus fasciolaris	**Kidneyshell**	**SH**	**Y**	**Y**	**Y**	**SH**	**SH**	**-**	**-**	**-**	**-**	**-**	**-**
Pyganodon cataracta[1]	Eastern Floater	-	-	-	Y	-	-	-	-	-	-	-	-
Pyganodon grandis	Giant Floater	Y	Y	Y	Y	Y	Y	-	Y	-	Y	Y	SH
Quadrula pustulosa	Pimpleback	SH	Y	Y	Y	Y	Y	-	-	-	SH	-	-
Quadrula quadrula	**Mapleleaf**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**-**	**-**	**-**	**Y**	**-**	**-**
Simpsonaias ambigua	**Salamander Mussel**	**-**	**SH**	**Y**	**Y**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Strophitus undulatus	Creeper	Y	Y	Y	Y	Y	Y	-	-	-	-	-	Y
Toxolasma parvum	Lilliput	Y	Y	Y	Y	SH	Y	-	Y	-	Y	-	-
Truncilla donaciformis	**Fawnsfoot**	**-**	**Y**	**SH**	**Y**	**SH**	**Y**	**-**	**-**	**-**	**-**	**-**	**Y**
Truncilla truncata	Deertoe	Y	Y	Y	Y	SH	Y	-	-	-	SH	-	-
Utterbackia imbecillis	Paper Pondshell	-	Y	Y	Y	SH	Y	-	Y	-	-	-	-
Villosa fabalis	**Rayed Bean**	**SH**	**Y**	**Y**	**Y**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Villosa iris	**Rainbow Mussel**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**-**	**-**	**-**	**-**	**Y**	**Y**
Species Richness		32	33	34	34	32	27	1	5	0	11	9	14
Overall Species Richness		35		35		32		6		11		14	

[1] These records are considered erroneous, based on species distribution, and are not included in the species richness

Y represents live individuals

SH represents shells only

Table 3. Physical characteristics for all sites surveyed by Fisheries and Oceans Canada in 2010. Thames River tributaries include Baptiste Creek (TR-54, TR-55) and Jeannette's Creek (TR-56), Lake St. Clair tributaries include the Belle (BLR) and Ruscom (RS) rivers. GR-36 was the only site surveyed in the Grand River. Substrate types were modified from Wentworth (1922): boulder is >250 mm in size, rubble is between 60-250 mm in size, gravel is between 20-50 mm in size, and sand is <20 mm in size. "Other" includes muck, mud, silt, and detritus. N/A – data not collected.

Site	Substrate (%)					Water clarity (m)	Site length (m)	Mean width (m)	Mean depth searched (m)	Stream morphology (%)			
	Boulder	Rubble	Gravel	Sand	Other					Riffle	Run	Pool	Flat
TR-54	0	5	30	45	20	0.20	600	4	0.25	20	70	10	0
TR-55	10	0	10	10	70	N/A	704	14	1	0	100	0	0
TR-56	0	5	10	40	45*	poor	96	50	1.25	0	90	10	0
BLR-01	0	5	0	10	85	N/A	200	4	0.35	0	95	5	0
BLR-02	0	0	8	7	85	fairly clear	250	4	0.35	0	100	0	0
BLR-03	0	0	5	0	95	0.05 m	50	7	0.3	0	50	50	0
RS-01	0	10	30	10	50	0.1-0.4 m	250	1	0.2	20	60	20	0
RS-02	0	5	10	15	70	0.4 m	150	3	0.3	5	90	5	0
RS-03	0	0	5	30	65	poor	140	10	0.4	0	100	0	0
RS-04	5	10	15	10	60	0.2 m	160	3	0.3	10	80	10	0
RS-05	0	0	0	90	10	N/A	15	3	0.8	0	100	0	0
RS-06	0	10	0	40	50	0.15 m	25	3	0.6	0	100	0	0
GR-36	30	20	30	10	10	clear	100	10	0.5	75	25	0	0

* 5% of substrate was concrete

Table 4. Physical characteristics for all sites surveyed in the Sydenham and Grand rivers by Fisheries and Oceans Canada in 2011. SR = Sydenham River, GR = Grand River. Substrate types were modified from Wentworth (1922): boulder is >250 mm in size, rubble is between 60-250 mm in size, gravel is between 20-50 mm in size, and sand is <20 mm in size. "Other" includes muck, mud, silt, and detritus. N/A – data not collected.

Site	Substrate (%)					Water clarity (m)	Site length (m)	Mean width (m)	Mean depth searched (m)	Stream morphology (%)			
	Boulder	Rubble	Gravel	Sand	Other					Riffle	Run	Pool	Flat
SR-21	0	0	60	0	40[1]	0.32	50	1.5	1.2	0	0	0	100
SR-22	0	5	40	0	55	0.18	30	6	0.6	0	100	0	0
GR-05	0	30	10	5	55	0.85	100	45	0.6	0	60	40	0
GR-06	0	60	25	10	5	0.6	100	90	0.3	20	75	5	0
GR-07	0	0	0	0	100	0.6	60	NA	0.65	0	20	80	0
GR-10	5	10	10	10	65	0.57	50	NA	0.40	0	20	0	80
GR-17	10	30	40	10	20	0.19	40	40	1.0	0	100	0	0

[1] All clay

Table 5. Physical characteristics for all sites surveyed by Fisheries and Oceans Canada in the Saugeen River in 2011. Substrate types were modified from Wentworth (1922): boulder is >250 mm in size, rubble is between 60-250 mm in size, gravel is between 20-50 mm in size, and sand is <20 mm in size. "Other" includes muck, mud, silt, and detritus. N/A – data not collected.

Site	Substrate (%)					Water clarity (m)	Site length (m)	Mean width (m)	Mean depth searched (m)	Stream morphology (%)			
	Boulder	Rubble	Gravel	Sand	Other					Riffle	Run	Pool	Flat
SG01	NA	NA	NA	NA	NA	0.45	NA	NA	0.45	40	20	40	0
SG04	20	60	10	5	5	> 1.2	250	15	0.75	10	70	20	0
DM11	NA	NA	NA	NA	NA	0.75	100	25	0.30	NA	NA	NA	NA
DM12	NA	NA	NA	NA	NA	0.62	150	25	NA	NA	NA	NA	NA
SG08	NA	NA	NA	NA	NA	1.17	200	50	0.53	65	20	15	0
SG09	NA	NA	NA	NA	NA	0.56	60	16.5	0.60	0	80	20	0
SG13	NA	NA	NA	NA	NA	0.60	N/A	22	0.70	5	95	0	0
SG10*	10	50	10	10	0	0.96	450	NA	0.40	NA	NA	NA	NA
SG11	NA	NA	NA	NA	NA	0.56	65	NA	0.30	NA	NA	NA	NA
SG12	10	60	15	5	10	1.15	400	20	0.5	10	25	20	45
SG14	10	80	5	5	0	0.63	10	15	0.50	NA	NA	NA	NA
SG15	0	0	40	0	60	0.26	10	15	0.60	0	0	0	100

* 20% of substrate was bedrock

Table 6. Number of live specimens collected at the sites surveyed in the Thames River tributaries in 2010. No mussels or shells were collected at site TR-54 in Baptiste Creek. TR-55 is in Baptiste Creek and TR-56 is in Jeanette's Creek. SH refers to the presence of shells.

		Site				
Species Name	**Common Name**	**TR-55**[1]	**TR-56**	**Total Abundance**	**Relative Abundance (%)**	**Frequency of Occurrence (%)**
Lasmigona complanata	White Heelsplitter	0	SH	0	0	0
Pyganodon grandis	Giant Floater	0	1	1	7.69	50
*Quadrula quadrula**	Mapleleaf	9	0	9	69.23	50
Toxolasma parvum	Lilliput	1	0	1	7.69	50
Truncilla truncata	Deertoe	1	0	1	7.69	50
Utterbackia imbecillis	Paper Pondshell	1	0	1	7.69	50
Total		**12**	**1**	**13**		
Species Richness (extant)		**4**	**1**	**5**		

* See Table 1 for assessment and listing

[1] Zebra Mussel shells present but no live individuals observed

Table 7. Number of live specimens collected at each site surveyed in the Belle (BLR) and Ruscom (RS) rivers by Fisheries and Oceans Canada in 2010. No mussels or shells were found at sites BLR-01 or RS-05. SH refers to the presence of shells.

Species Name	Common Name	Site							Total Abundance	Relative Abundance (%)	Frequency of Occurrence (%)
		BLR-02	BLR-03	RS-01	RS-02	RS-03	RS-04	RS-06			
Anodontoides ferussacianus	Cylindrical Papershell	0	0	0	10	SH	0	0	10	2.82	11.11
Lasmigona complanata	White Heelsplitter	SH	9	SH	2	7	9	0	27	7.61	44.44
Lampsilis silquoidea	Fatmucket	0	0	0	3	0	236	0	239	67.32	22.22
Leptodea fragilis	Fragile Papershell	0	0	0	0	0	1	1	2	0.56	22.22
Ligumia recta	Black Sandshell	0	0	0	0	0	1	0	1	0.28	11.11
Pyganodon grandis	Giant Floater	SH	3	SH	0	1	40	0	44	12.39	33.33
*Quadrula quadrula**	Mapleleaf	0	0	0	0	2	24	0	26	7.32	22.22
Toxolasma parvum	Lilliput	0	2	0	0	0	SH	3	5	1.41	22.22
Utterbackia imbecilis	Paper Pondshell	0	1	0	0	0	0	0	1	0.28	11.11
Total		**0**	**15**	**0**	**15**	**10**	**311**	**4**	**355**		
Species Richness (extant)		**0**	**4**	**0**	**3**	**3**	**6**	**2**	**9**		

* See Table 1 for assessment and listing

Table 8. Number of live specimens collected at SR-21 and SR-22 in the Sydenham River by Fisheries and Oceans Canada during 2011 timed search surveys. WS represents weathered shells.

Species Name	Common Name	SR-21	SR-22	Total Abundance	Relative Abundance (%)
Amblema plicata	Threeridge	0	1	1	5.26
Fusconaia flava	Wabash Pigtoe	0	WS	0	0.00
Potamilus alatus	Pink Heelsplitter	2	0	2	10.53
Pyganodon grandis	Giant Floater	1	4	5	26.32
*Quadrula quadrula**	Mapleleaf	WS	1	1	5.26
Toxolasma parvum	Lilliput	0	7	7	36.84
Utterbackia imbecillus	Paper Pondshell	0	3	3	15.79
Total		**3**	**15**	**19**	
Species Richness (extant)		**2**	**5**	**6**	

* See Table 1 for assessment and listing

Table 9. Number of live specimens collected at GR-36 in the Grand River by Fisheries and Ocean Canada during 2010 timed search surveys.

Species Name	Common Name	Total Abundance	Relative Abundance (%)
Actinonaias ligamentina	Mucket	1	3.33
Alasmodonta marginata	Elktoe	5	16.67
*Lampsilis fasciola**	Wavyrayed Lampmussel	8	26.67
Lasmigona costata	Flutedshell	16	53.33
Total		**30**	
Species Richness (extant)		**4**	

* See Table 1 for assessment and listing

Table 10. Number of live specimens, shells, and collection effort (number of person hours) in the Grand River by Fisheries and Oceans Canada during initial freshwater mussel scouting surveys in June 2011. SH represents shells and V represents valves - those in **bold** were considered fresh.

Species Name	Common Name		GR-05	GR-06	GR-07	GR-16[1]	GR-17	GR-34[2]
		Effort	**1.5**	**4.5**	**0.5**	**?**	**0.17**	**0.67**
Actinonaias ligamentina	Mucket		0	9	0		**V**	0
Alasmidonta marginata	Elktoe		SH	1	0		0	0
Fusconaia flava	Wabash Pigtoe		0	V	0		0	0
Lasmigona complanata	White Heelsplitter		0	0	SH		0	0
Lasmigona costata	Flutedshell		0	3	0		0	0
Leptodea fragilis	Fragile Papershell		0	V	0		0	0
Ligumia recta	Black Sandshell		0	2	0		0	0
Obliquaria reflexa	Threehorn Wartyback		0	**V**	0		0	0
Potamilus alatus	Pink Heelsplitter		0	1	0		0	0
Pyganodon grandis	Giant Floater		0	V	0		0	0
Quadrula pustulosa	Pimpleback		0	4	0		0	0
*Quadrula quadrula**	Mapleleaf		0	1	0		0	0
Toxolasma parvum	Lilliput		0	0	0		0	V
Truncilla truncata	Deertoe		0	6	0	V	**V**	0

* See Table 1 for assessment and listing

[1] Too deep to survey

[2] Surveyed using a different technique (half hectare plots), which will be reported in another manuscript.

Table 11. Number of live specimens and presence of shells in the Grand River during freshwater mussel timed searches in August 2011 by Fisheries and Ocean Canada. SH represents shells and V represents valves - those in **bold** were considered fresh.

Species Name	Common Name	GR-05	GR-06	GR-07	GR-10	GR-17	Total Abundance	Relative Abundance (%)	Frequency of Occurrence (%)
Actinonaias ligamentina	Mucket	4	97	0	1	0	102	21.56	60.00
Alasmidonta marginata	Elktoe	1	6	0	0	0	7	1.48	40.00
Amblema plicata	Threeridge	2	0	0	1	0	3	0.63	40.00
Lampsilis cardium	Plain Pocketbook	0	10	0	0	0	10	2.11	20.00
Lasmigona compressa	Creek Heelsplitter	0	1	0	0	0	1	0.21	20.00
Lasmigona costata	Flutedshell	18	64	0	0	0	82	17.34	40.00
Leptodea fragilis	Fragile Papershell	0	21	0	1	0	22	4.65	40.00
Ligumia recta	Black Sandshell	9	65	0	0	0	74	15.64	40.00
Obliquaria reflexa	Threehorn Wartyback	**SH**	1	0	**V**	1	2	0.42	40.00
*Pleurobema sintoxia**	Round Pigtoe	2	6	0	0	0	8	1.69	40.00
Potamilus alatus	Pink Heelsplitter	16	21	0	2	0	39	8.25	60.00
Pyganodon grandis	Giant Floater	4	0	2	2	0	8	1.69	60.00
Quadrula pustulosa	Pimpleback	5	59	0	0	0	64	13.53	40.00
*Quadrula quadrula**	Mapleleaf	4	15	8	1	6	34	7.19	100.00
Toxolasma parvum	Lilliput	0	0	0	0	SH	0	0.00	0.00
Truncilla donaciformis	Fawnsfoot	0	0	0	SH	SH	0	0.00	0.00
Truncilla truncata	Deertoe	4	4	0	0	1	9	1.90	60.00
Strophitus undulatus	Creeper	1	0	0	0	0	1	0.21	20.00
Utterbackia imbecillus	Paper Pondshell	0	0	0	7	0	7	1.48	20.00
Unknown juveniles[1]		2	0	2	2	3	9	1.90	80.00
Total		**70**	**370**	**10**	**15**	**8**	**473**		
Species Richness (extant)		**12**	**13**	**2**	**7**	**3**	**17**		

* See Table 1 for assessment and listing,
[1]Not included in Total or Species Richness

Table 12. Number of live specimens collected by Fisheries and Oceans Canada in the Saugeen River in 2011. SH represents shells and V is the presence of a single valve, those in bold are fresh shells. Live refers the presence of live individuals, without specific numbers.

Species Name	Common Name	SG01	SG04	SG08	SG09	SG15	SG13	SG10	SG11	SG12	SG14	DM11[1]	DM12[1]	Total Abundance	Relative Abundance (%)	Frequency of Occurrence (%)
Actinonaias ligamentina	Mucket	0	0	0	0	V	0	0	0	0	0	0	0	**0**	**0.00**	**0**
Alasmidonta marginata	Elktoe	0	Live	SH	0	0	0	1	0	5	0	6	5	**17**	**2.47**	**33.33**
Alasmidonta viridis	Slippershell	0	0	SH	0	0	0	0	0	0	0	0	0	**0**	**0.00**	**0**
Anodontoides ferussancianus	Cylindrical Papershell	0	0	0	SH	0	0	0	0	0	0	0	0	**0**	**0.00**	**0**
Elliptio dilatata	Spike	0	Live	Live	6	0	0	27	Live	214	285	12	17	**561**	**81.54**	**66.67**
Lampsilis cardium	Plain Pocketbook	0	0	Live	1	**SH**	2	0	0	2	0	0	0	**5**	**0.73**	**33.33**
Lampsilis silquoidea	Fatmucket	0	0	SH	2	0	1	0	0	0	0	0	0	**3**	**0.44**	**16.67**
Lasmigona complanata	White Heelsplitter	0	SH	0	0	0	0	0	0	0	0	0	0	**0**	**0.00**	**0**
Lasmigona compressa	Creek Heelsplitter	0	0	0	0	0	0	0	0	2	0	0	0	**2**	**0.29**	**8.33**
Lasmigona costata	Flutedshell	0	0	0	31	0	0	5	0	3	0	0	1	**40**	**5.81**	**33.33**
Pyganodon grandis	Giant Floater	0	0	0	**SH**	0	0	0	0	0	0	0	0	**0**	**0.00**	**0**
Strophitus undulatus	Creeper	0	0	SH	1	0	0	0	0	4	0	0	SH	**5**	**0.73**	**16.67**
*Villosa iris**	Rainbow Mussel	SH	0	0	**SH**	0	0	8	Live	12	24	1	10	**55**	**7.99**	**50**
Total		**0**	**Live**	**Live**	**41**	**0**	**3**	**41**	**Live**	**242**	**309**	**19**	**33**	**688**		
Species Richness (extant)		**0**	**2**	**2**	**5**	**0**	**2**	**4**	**2**	**7**	**2**	**3**	**4**	**8**		

* See Table 1 for assessment and listing

[1] Approximate number

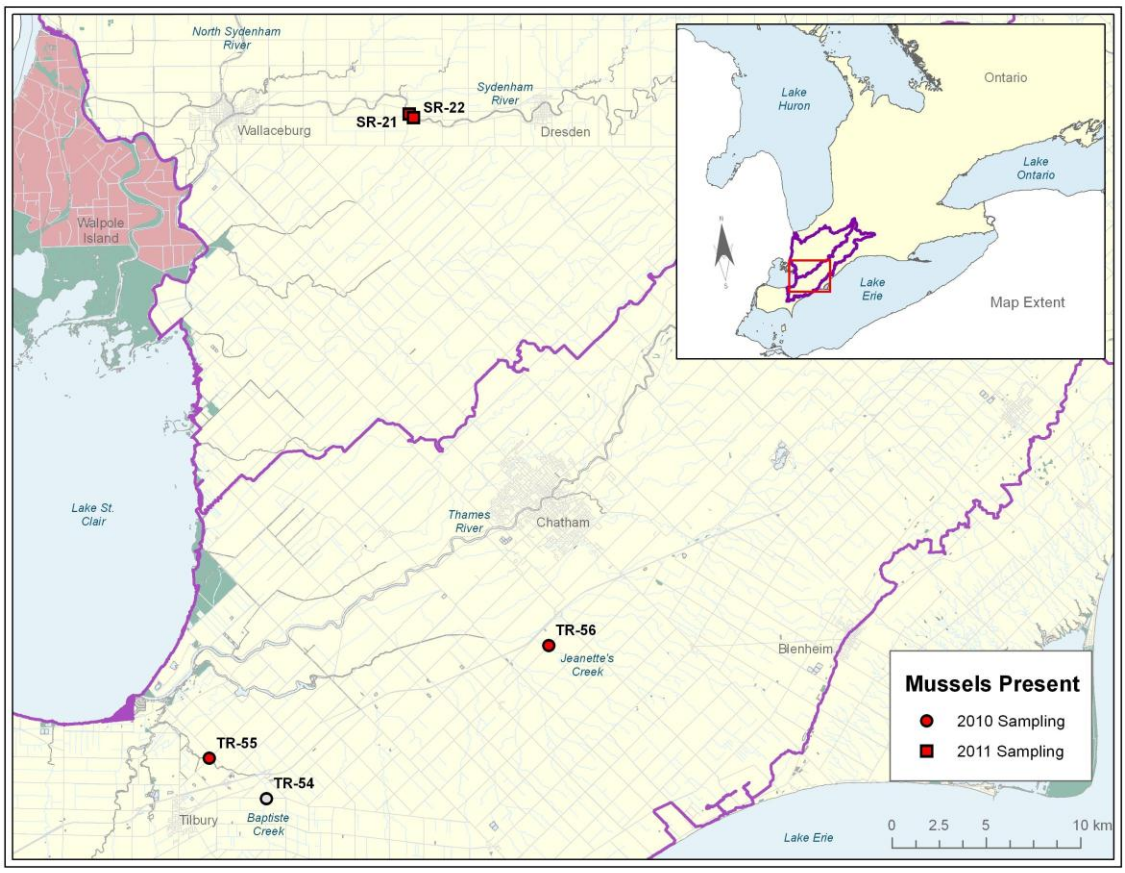

Figure 1. All sites sampled in Baptiste and Jeannette's Creek of the Thames River watershed (outlined in purple) in 2010 and in the Sydenham River in 2011 by Fisheries and Oceans Canada. Open shapes represent sites where no live mussels were observed. Site number corresponds to numbers in the Tables 3, 4, 6 and 8 and Appendices A and B.

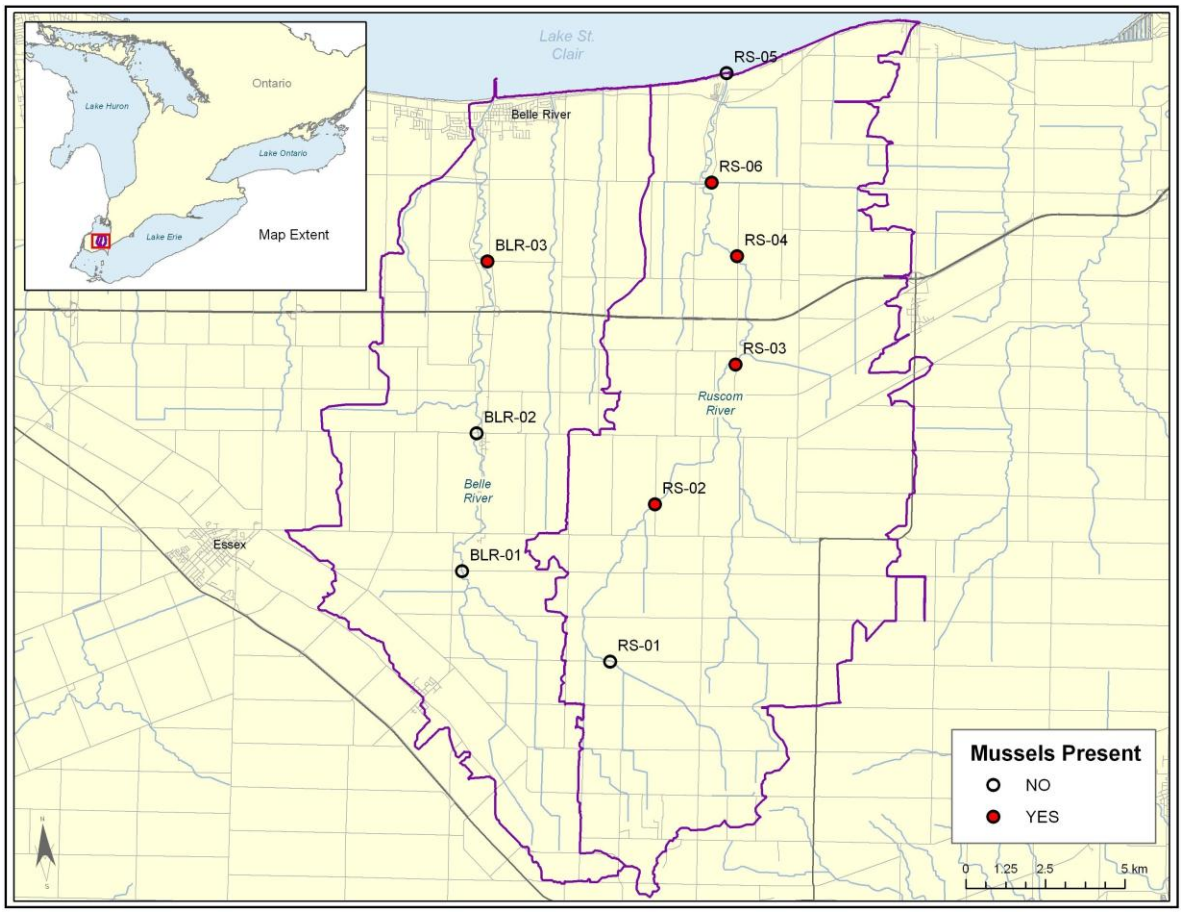

Figure 2. All sites sampled in Belle and Ruscom rivers in 2010 by Fisheries and Oceans Canada. Watersheds are outlined in purple. Open circles represent sites where no live mussels were found. Site number corresponds to numbers in Tables 3 and 7 and Appendix A.

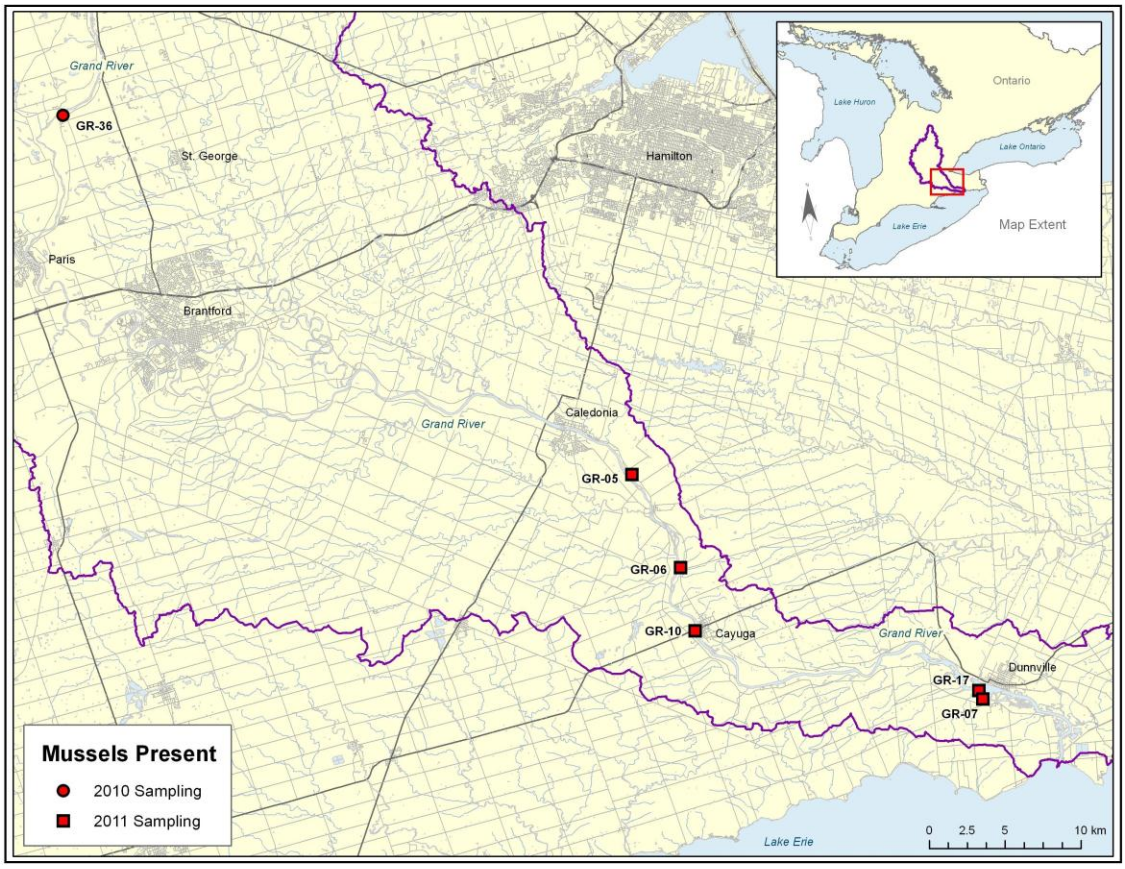

Figure 3. Grand River sites surveyed in 2010 and 2011 by Fisheries and Oceans Canada. Site number corresponds to numbers in the Tables 3, 4, 9 and 11 and Appendices A and B. GR-16 is not included because it was too deep to properly survey and GR-34 will be presented in another manuscript report.

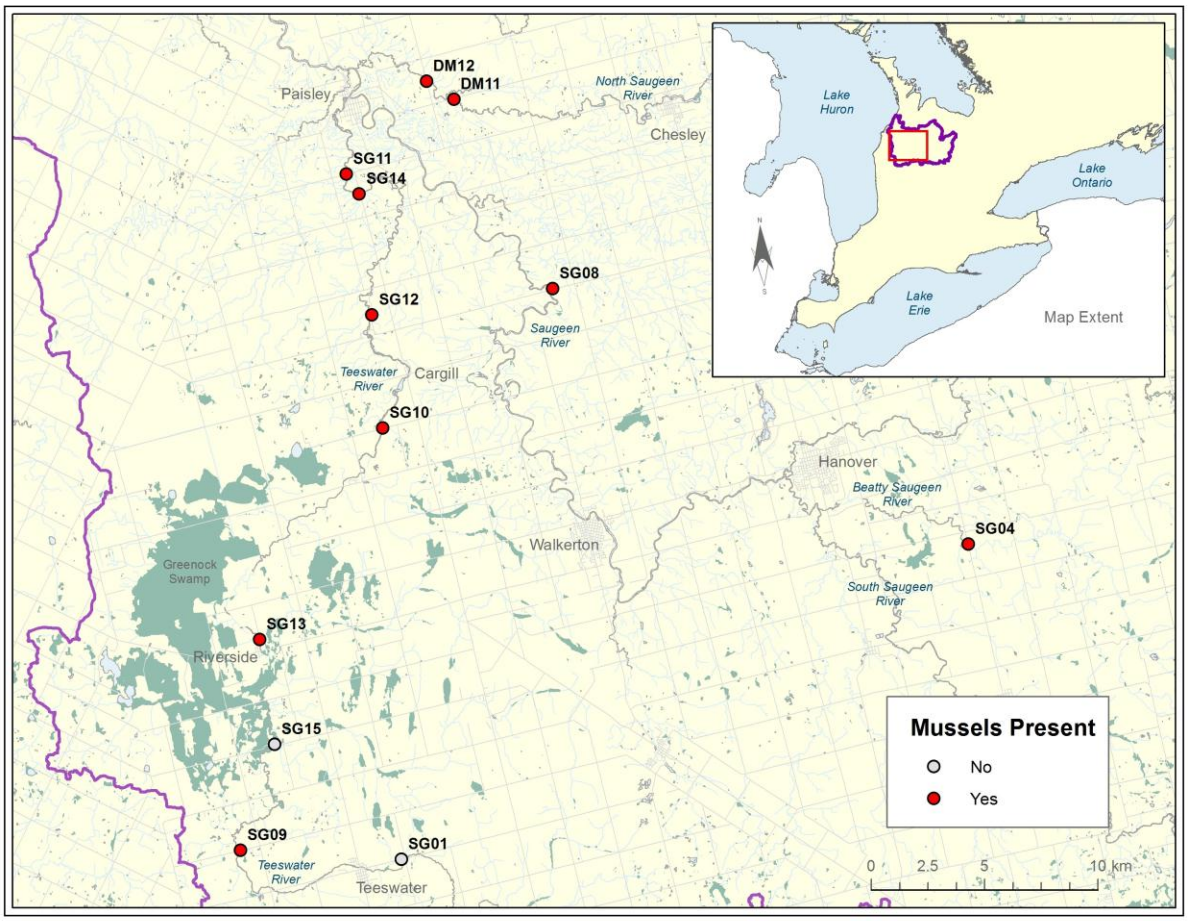

Figure 4. Saugeen River sites surveyed in 2011 by Fisheries and Oceans Canada. Open shapes represent sites where no live mussels were observed. Saugeen River watershed is outlined in purple. Site number corresponds to numbers in Tables 5 and 12 and Appendix C.

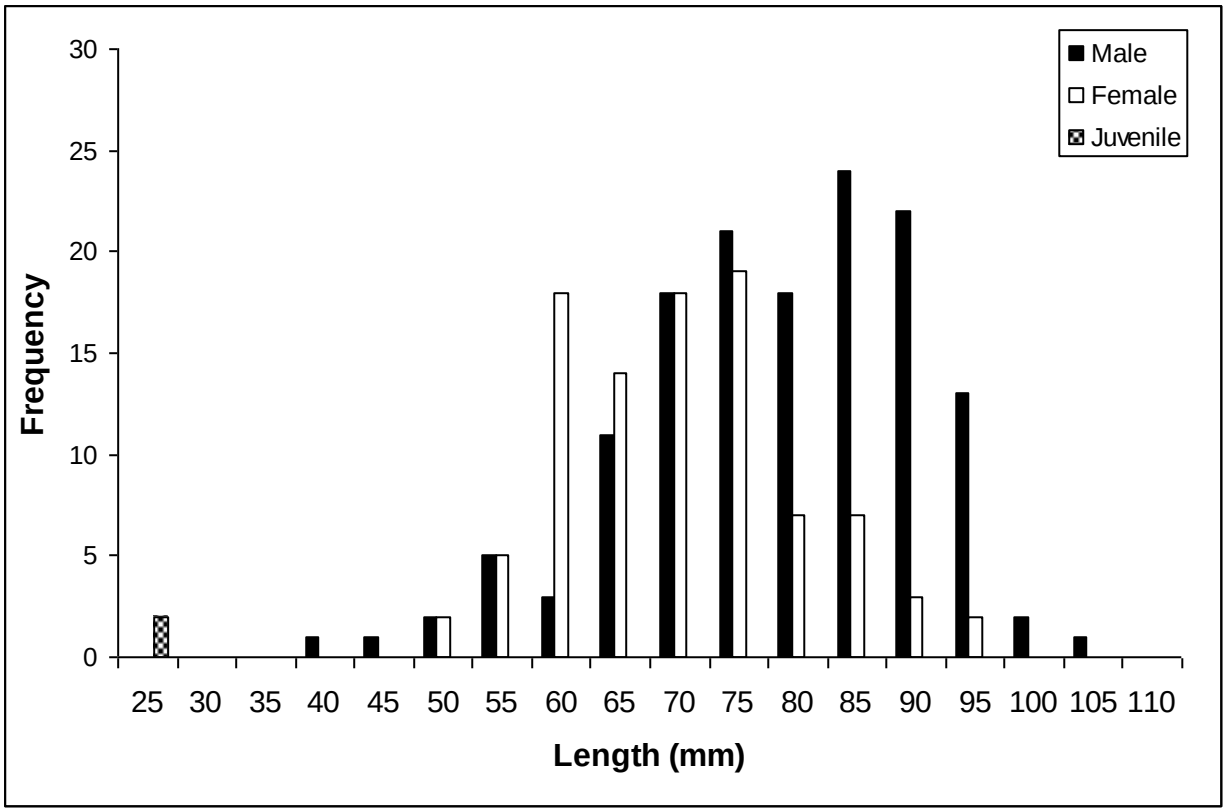

Figure 5. Length frequency distribution for male (n = 142), female (n = 95) and juvenile (n = 2) *Lampsilis siliquoidea* (Fatmucket) found at two sites (RS-02, RS-04) in the Ruscom River in 2010 by Fisheries and Oceans Canada.

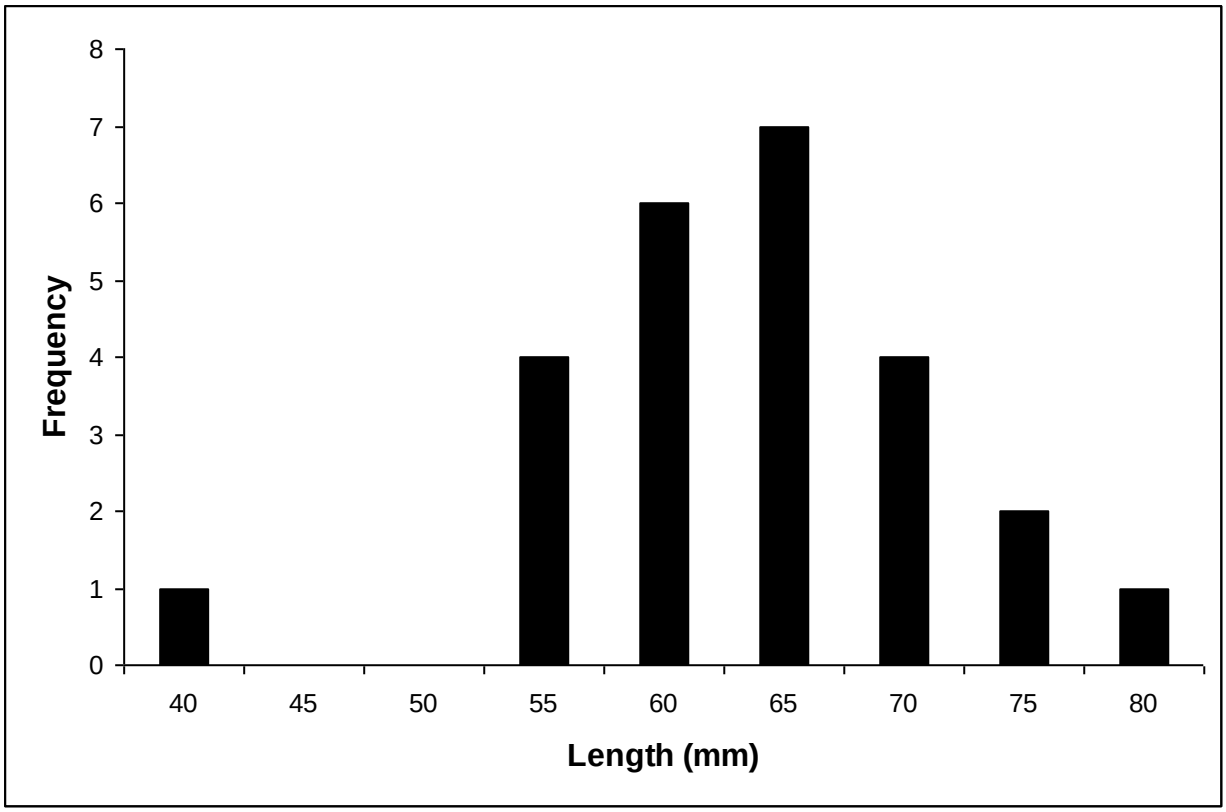

Figure 6. Length frequency distribution for *Quadrula quadrula* (Mapleleaf Mussel) found in the Ruscom River in 2010 by Fisheries and Oceans Canada (N = 26).

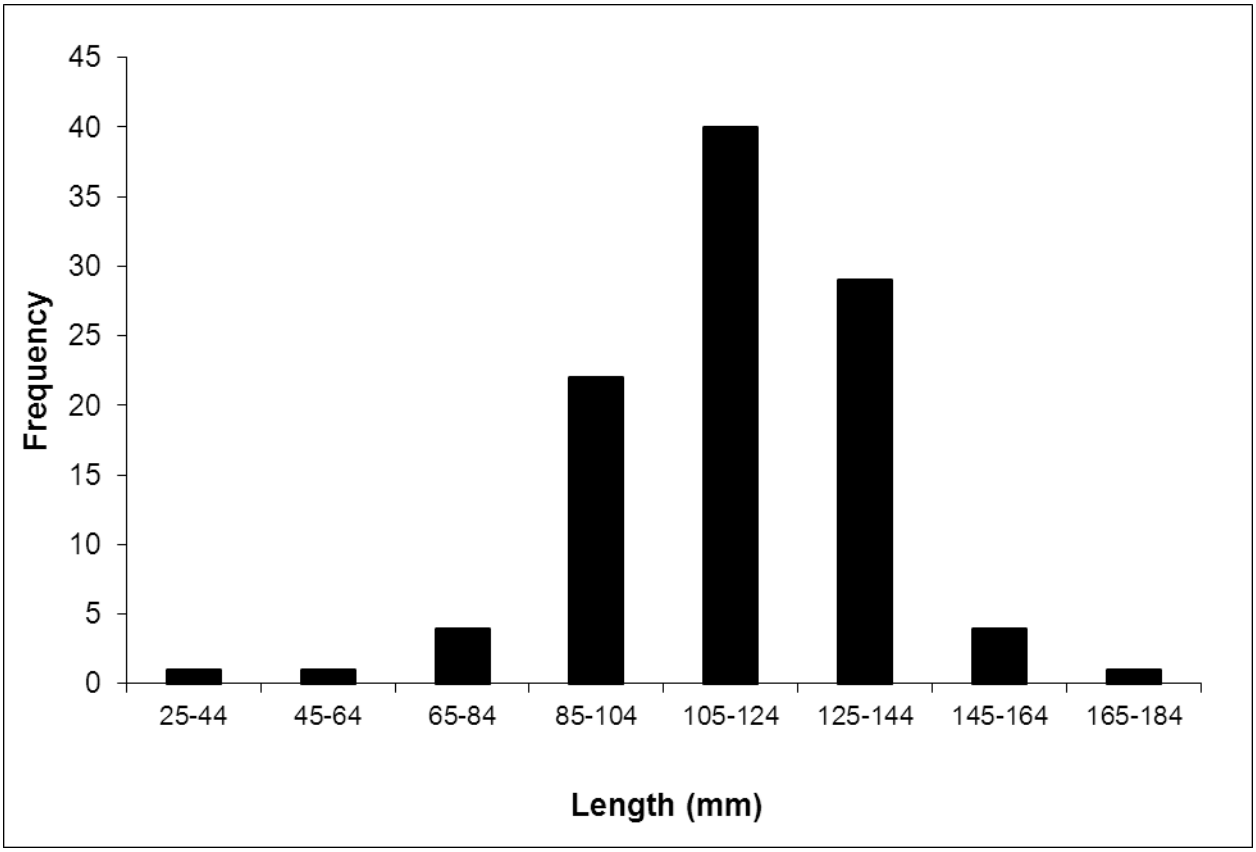

Figure 7. Length frequency distribution for *Actinonaias ligamentina* (Mucket) found in the Grand River in 2011 by Fisheries and Oceans Canada (N = 102).

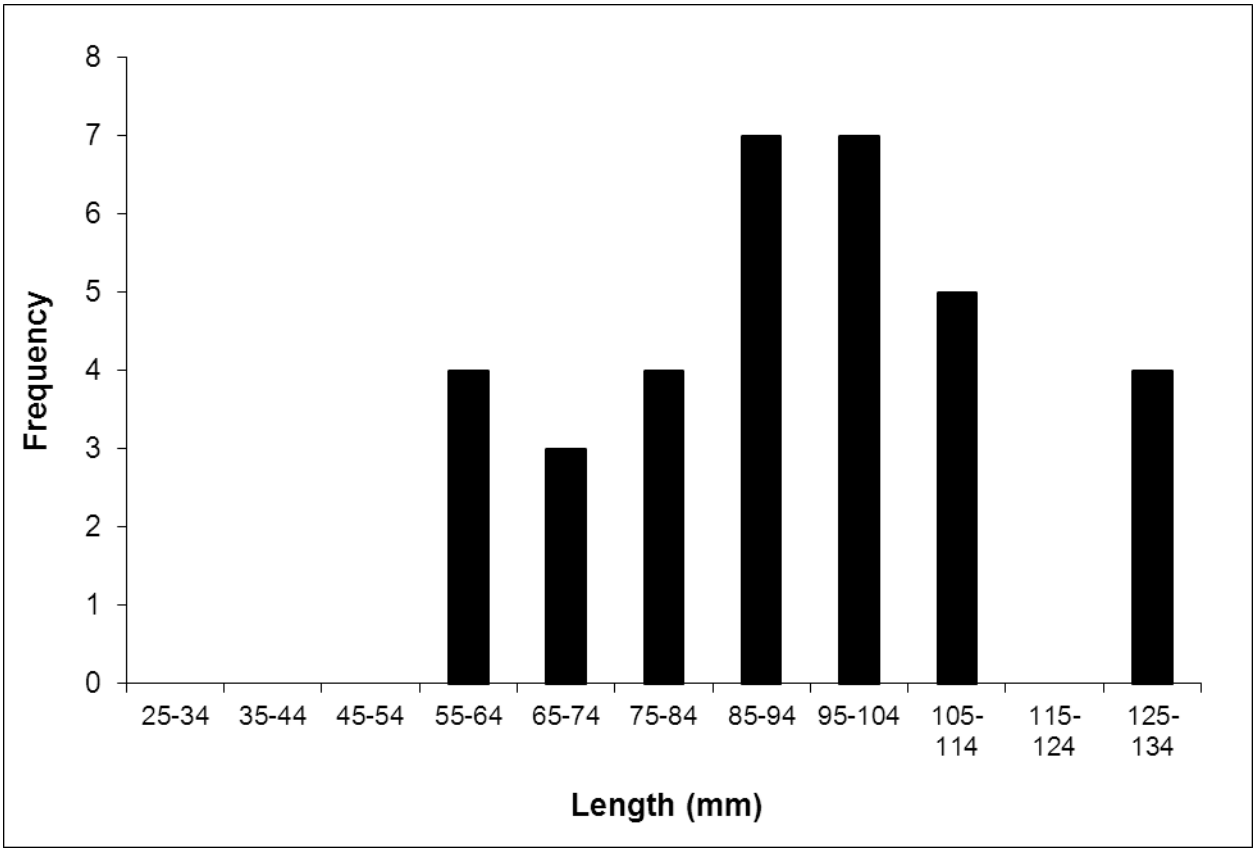

Figure 8. Length frequency distribution for *Quadrula quadrula* (Mapleleaf Mussel) found in the Grand River in 2011 by Fisheries and Oceans Canada (N = 34).

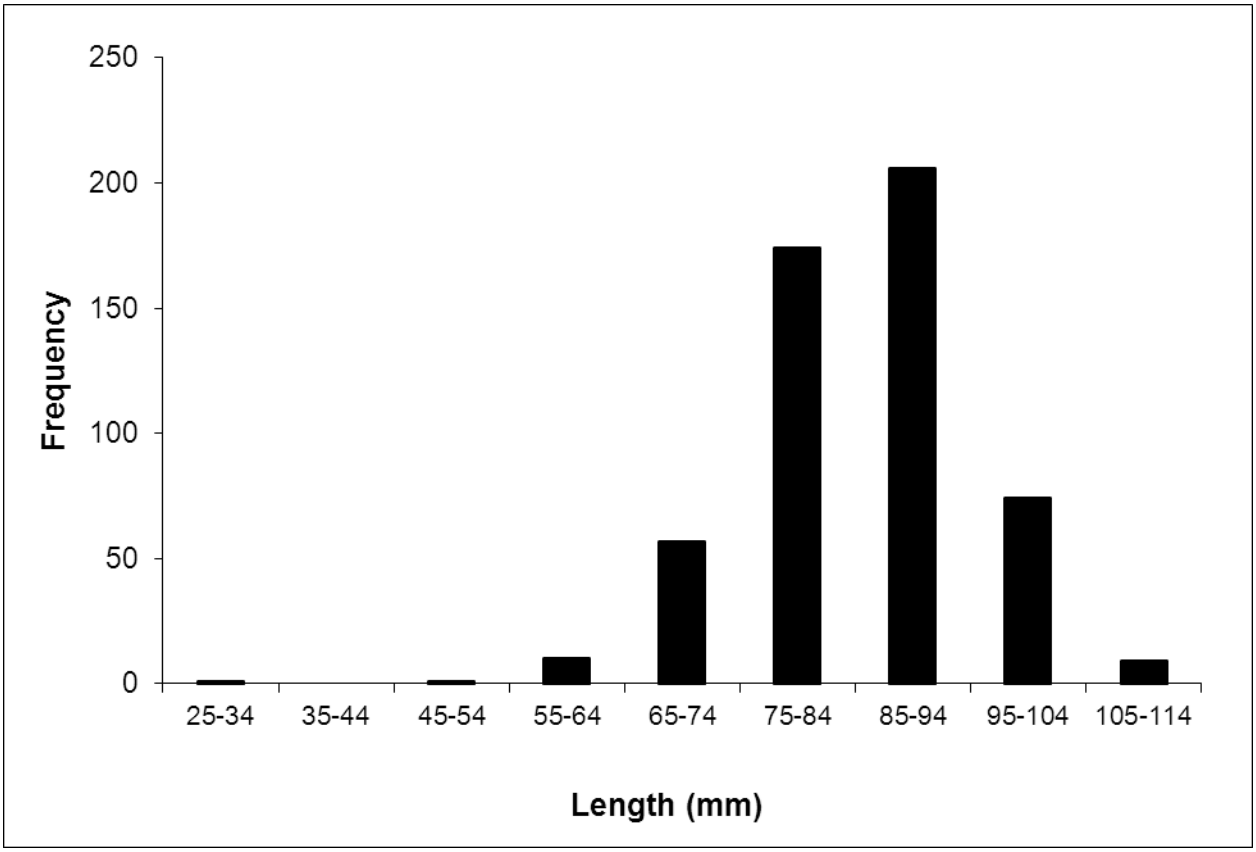

Figure 9. Length frequency distribution for *Elliptio dilatata* (Spike) found in the Saugeen River in 2011 by Fisheries and Oceans Canada (N = 532).

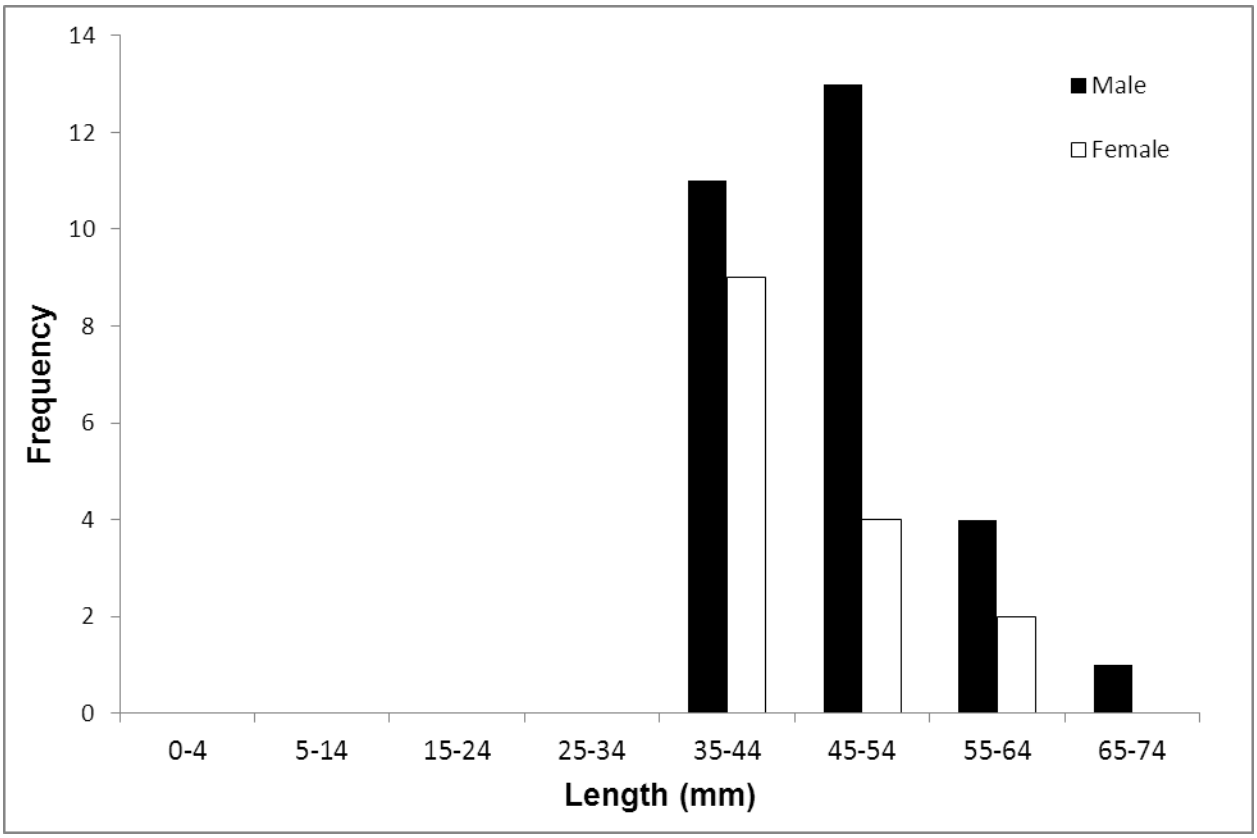

Figure 10. Length frequency distribution for male (n=29) and female (n=15) *Villosa iris* (Rainbow Mussel) found in the Saugeen River in 2011 by Fisheries and Oceans Canada.

Appendix A. Site descriptions, collectors and effort (person hours) expended for Baptiste and Jeannette's creeks in the Thames River watershed, the Belle (BLR) and Ruscom (RS) rivers of the Lake St. Clair watershed, and in the Grand River. Sites were surveyed by Fisheries and Oceans Canada in 2010.

Site	Date	Latitude	Longitude	Waterbody	Watershed	Local Description	Effort	Collectors
TR-54	15/06/10	42.26774	-82.37525	Baptiste Creek	Thames River	Pollard Line	9	Minke-Martin, Marson, Robinson
TR-55	16/06/10	42.28785	-82.41109	Baptiste Creek	Thames River	Tilbury	4.5	Minke-Martin, Marson, Robinson
TR-56	18/06/10	42.33590	-82.19061	Jeannette's Creek	Thames River	Hwy 14	3	Minke-Martin, Marson, Robinson
BLR-01	03/08/10	42.16401	-82.7276	Belle River	Lake St. Clair	Mersea Rd. 11, bridge crossing	1	Minke-Martin, Marson, Robinson
BLR-02	04/08/10	42.20271	-82.72058	Belle River	Lake St. Clair	South Middle Road near Woodslee	2	Minke-Martin, Marson, Robinson
BLR-03	06/08/10	42.25112	-82.71449	Belle River	Lake St. Clair	Lion's Club Rd/Roger's Rd	2.25	Minke-Martin, Marson, Robinson
RS-01	04/08/10	42.13716	-82.67250	Ruscom River	Lake St. Clair	Hwy 14	2	Minke-Martin, Marson, Robinson
RS-02	04/08/10	42.18117	-82.65369	Ruscom River	Lake St. Clair	Lakeshore Rd 235, N of Hwy 8	unknown	Minke-Martin, Marson, Robinson
RS-03	04/08/10	42.21993	-82.62143	Ruscom River	Lake St. Clair	Mitchell Rd	4.5	Minke-Martin, Marson, Robinson
RS-04	05/08/10	42.25045	-82.61957	Ruscom River	Lake St. Clair	Lakeshore Rd 129	4.5	Minke-Martin, Marson, Robinson
RS-05	05/08/10	42.30214	-82.62130	Ruscom River	Lake St. Clair	Ruston Drive	1.5	Minke-Martin, Marson, Robinson
RS-06	05/08/10	42.27139	-82.62832	Ruscom River	Lake St. Clair	Hwy 42 - Division Rd.	2	Minke-Martin, Marson, Robinson
GR-36	26/05/10	43.27667	-80.34565	Grand River	Grand River	Downstream of Glen Morris	3.8	Marson, Robinson

Appendix B. Site descriptions, collectors and effort (number of person hours) expended for the Sydenham and Grand rivers by Fisheries and Oceans Canada in 2011.

Site	Date	Latitude	Longitude	Waterbody	Watershed	Local Description	Effort	Collectors	Comments
SR-21	17/08/11	42.591550	-82.26813	Sydenham River	Sydenham River	Downstream of bridge in Tupperville	4.5	Read, Esteves, Martin	
SR-22	17/08/11	42.58977	-82.26542	Sydenham River	Sydenham River	End of Broad Line, Tupperville	4.5	Read, Esteves, Martin	
GR-05	03/08/11	43.04299	-79.90491	Grand River	Grand River	Rotary Riverside Trail parking lot	6.0	Esteves, Read, Martin, Kelly	
GR-06	03/08/11	42.98624	-79.87069	Grand River	Grand River	Between York and Cayuga	5.75	Esteves, Read, Martin, Kelly	
GR-07	04/08/11	42.90139	-79.63750	Grand River	Grand River	Byng Park	6	Esteves, Read, Martin, Hosick	
GR-10	05/08/11	42.94813	-79.86252	Grand River	Grand River	Cayuga	5.5	Esteves, Read, Martin	
GR-16	10/06/11	42.8612	-79.57419	Grand River	Grand River	Port Maitland, east of boat launch	?	Esteves, Read, Martin	No live mussels found
GR-17	05/08/11	42.89621	-79.63492	Grand River	Grand River	Byng Island	5.5	Esteves, Read, Martin	
GR-34	09/06/11	42.89698	-79.61662	Grand River	Grand River	Private marina	0.67	Esteves, Read, Martin	Searched using a different technique

Appendix C. Site descriptions, collectors and effort (number of person hours) expended for the Saugeen River watershed by Fisheries and Oceans Canada in in 2011.

Site	Date	Latitude	Longitude	Waterbody	Watershed	Local Description	Effort	Collectors	Comments
SG04	20/06/11	44.11703	-80.94364	Beatty Saugeen River	Saugeen River	County Rd.3, bridge crossing	?	Read, Esteves, Martin	Bridge rebuilt in 2010, busy road
DM11	20/06/11	44.30377	-81.21482	North Saugeen River	Saugeen River	County Rd. 11	1.5	Read, Esteves, Martin	Lots of Spike and Elktoe shells
DM12	20/06/11	44.31156	-81.22948	North Saugeen River	Saugeen River	Bridge crossing at sideroad 5	1.5	Read, Esteves, Martin	
SG08	20/06/11	44.2269	-81.1655	Saugeen River	Saugeen River	Concession 10 bridge	1.5	Read, Esteves, Martin	New bridge within last year, lots of Elktoe and Spike shells
SG01	21/06/11	44.00368	-81.26429	Teeswater River	Saugeen River	Bridge east of Teeswater	1.5	Read, Esteves, Martin	No live animals, lots of Rainbow shells
SG09	21/06/11	44.01038	-81.35247	Teeswater River	Saugeen River	Concession 8 bridge (west of sideroad 10)	4.5	Read, Esteves, Martin	
SG13	21/06/11	44.09351	-81.33642	Teeswater River	Saugeen River	Bridge St. and sideroad 20 bridge	1.5	Read, Esteves, Martin	
SG10	21/06/11	44.17500	-81.26299	Teeswater River	Saugeen River	Concession 8 bridge (eest of sideroad 5)	4.5	Read, Esteves, Martin	
SG11	22/06/11	44.27623	-81.27625	Teeswater River	Saugeen River	Concession Rd. 20	1.5	Read, Esteves, Martin	Spike and Rainbow in fairly high densities
SG12	28/07/11	44.22004	-81.26589	Teeswater River	Saugeen River	Banting Line	4.5	Read, Esteves, Martin	
SG14	21/06/11	44.268198	-81.269678	Teeswater River	Saugeen River	Greenock-Elderslie Townline bridge	1.5	Read, Esteves, Martin	
SG15	28/07/11	44.05174	-81.33098	Teeswater River	Saugeen River	Concession Rd. 12 bridge	0.5	Read, Esteves, Martin	